TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 175. MAY, 1915.

DIVISION OF CHEMISTRY

Distribution and Digestibility of the Pentosans of Feeds.

POSTOFFICE:
COLLEGE STATION, BRAZOS COUNTY, TEXAS

VON BOECKMANN-JONES CO., PRINTERS, AUSTIN, TEXAS
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BY

G. S. FRAPS,
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†As of May 1, 1915.

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DISTRIBUTION AND DIGESTIBILITY OF THE PENTOSANS OF FEEDS

BY G. S. FRAPS, PH. D., CHEMIST IN CHARGE; STATE CHEMIST.

This is a technical bulletin, being a report of work conducted with the Adams fund of the Federal government, the use of which is strictly limited to scientific investigation.

The furfural produced by the distillation of feeding stuffs with hydrochloric acid is generally ascribed to pentosans, which are bodies that yield pentose sugars upon hydrolysis. Other bodies than true pentosans produce furfural when distilled with hydrochloric acid, and some of these are found in plants. Oxycelluloses yield from 2 to 8 per cent furfural; the typical lignocellulose, jute, yields 9 to 10 per cent. (See Cross and Bevan Cellulose.) The oxycelluloses yield other bodies besides pentoses on hydrolysis and are more resistant to this process than are the true pentosans. We have, as yet, no chemical method for distinguishing sharply between the true pentosans, which yield pentose sugars, and the pseudo-pentosans, which yield furfural or some body similar to it, and do not yield pentose sugars in equivalent amounts.

The product of the distillation of plants with hydrochloric acid contains other substances besides furfural, as has been previously pointed out by the author. Insoluble fatty acids go over, which may be separated on a filter paper. When the distillate is allowed to stand ten hours, very often an amorphous black precipitate separates, which would appear in the precipitate which is weighed, either as such or combined with the phloroglucinol used to precipitate the furfural. The distillate also contains substances which precipitate with phloroglucinol but which are destroyed by a second distillation with the hydrochloric acid, while pure purfural is not so destroyed. (See Fraps, *Am. Chem. J.*, 25, p. 501 (1901). The term *furaloid* has been applied to these substances.

Methyl-pentosans, when present, give rise to methyl furfural.

DIGESTION EXPERIMENTS ON PENTOSANS.

A number of digestion experiments have been carried on with pentosans. Some digestion experiments with animals, and a discussion of previous work are given by Fraps, Bulletin 172, North Carolina Experiment Station, May, 1900. Lindsay gives a summary of the digestion experiments at the Massachusetts State Station in the annual report for 1902. Koenig and Reinhardt (abstract), Experiment Station Record 13, 877, show that pentosans are digested by man. McDowell (Penn. Report, 1906) gives some data, as well as McCullum and Brounon, *Jour. Am. Chem. Soc.*, 31, 1252 (1909), who also give a reference to bibliography of previous work.

Distribution of Pentosans.

Only a limited amount of American work has been done on this topic. Fraps, Bulletin 172, North Carolina Experiment Station, 1900, studied the distribution and digestibility of pentosans in the nitrogen-free extract and the crude fiber of several feeds. Frear, Report Pennsylvania Experiment Station, 1903-1904, studies the distribution of pentosans of timothy hay, as well as other constituents of this feed. Headden, Bulletin 124, Colorado Experiment Station, 1907, discusses the composition and digestibility of the constituents of a number of feeding stuffs, particularly with respect to their solubility in various solvents. The estimation of the pentosans dissolved was by difference. Some of the results with pentosans are given in Tables A and B.

TABLE A.—PERCENTAGE DISTRIBUTION OF PENTOSANS (HEADDEN).

	Alfalfa Hay.	Corn Fodder.	Sorghum Fodder.	Salt Bush.
Total	8.16	11.48	9.68	9.64
Soluble 80% alcohol	1.08	0.69	0.27	.00
Soluble cold water	0.59	0.03	.00	0.58
Soluble hot water	0.76	0.37	0.77	*1.45
Soluble 1% hydrochloric acid	1.51	5.05	5.31	2.90
Soluble 1% caustic soda	1.63	2.71	1.26	2.13
Soluble in chlorine	0.67	0.84	0.21	0.51
Residue	1.92	1.80	1.75	2.04

*And malt.

TABLE B.—COEFFICIENTS OF DIGESTIBILITY OF PENTOSANS (HEADDEN).

	Alfalfa Hay.	Timothy Hay.	Native Hay.	Corn Fodder.	Sorghum Fodder.	Salt Bush.
Total	65.2	50.1	50.6	60.2	45.5	37.4
Soluble 80% alcohol	96.5	69.5	61.9	94.8	22.9	0.0
Soluble cold water	100.0	71.1	6.8	100.0	0.0	0.0
Soluble hot water	67.4	0.0		100.0	0.0	*89.0
Soluble 1% hydrochloric acid	100.0	32.8	44.0	73.2	45.7	0.0
Soluble 1% caustic soda	27.8	11.5	42.2	31.8	25.4	46.4
Soluble chlorine, etc	0.0	98.5	0.0	32.6	48.7	26.5
Residue	72.6	50.1	74.9			

*And malt.

METHODS OF WORK.

The samples used were the feeds and excrements from the digestion experiments reported in Bulletin 147 of the Texas Experiment Station. Details of the routine digestion work are given in that bulletin.

Pentosans were determined by the methods of the Association of Official Agricultural Chemists.

Pentosans insoluble in N/50 acid and alkali were determined as follows: To two grams substance, previously extracted with ether, 200 c.c. boiling water was added and 20 c.c. of N/5 sulphuric acid. After boiling thirty minutes, 40 c.c. of N/5 caustic soda was added and the boiling continued fifteen minutes longer. It was then filtered on as-

bestos, washed, and pentosans estimated as usual in the residue. The solution is somewhat less than N/50 in strength.

Insoluble in One and One-fourth Per Cent Sulphuric Acid. The substance after extraction with ether was boiled thirty minutes with 1¼ per cent sulphuric acid as in the method for crude fiber, the residue from the acid being filtered on asbestos, and pentosans determined in it.

In Crude Fiber. Crude fiber was prepared by the usual method, the filtrations made on asbestos, the residue transferred to a flask and pentosans estimated.

In Nitrogen-free Extract. The difference between the total pentosans and the pentosans in the crude fiber is taken to be the pentosans in the nitrogen-free extract. A small amount of pentosans is destroyed by the reagents used in all these treatments. See the discussion on a subsequent page.

TABLE 1.—PENTOSANS IN PER CENT OF THE FEED.

Laboratory No.		Total.	In residue N/50 acid and alkali.	After 1¼% Sulphuric acid.	In crude fiber.	In Nitrogen-Free Extract			
						Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
3277	Alfalfa hay	13.53	7.63	7.80	4.16	9.37	5.90	.00	3.64
3609	Bur clover	12.54	6.36	6.08	2.62	9.92	6.18	.28	3.46
3220	Cowpea hay	11.28	.....	.....	3.73	7.55	.....	.....	.....
4259	Peanut hay	11.11	6.07	5.34	3.22	7.89	5.04	.73	2.12
3649	Vetch hay	13.19	7.96	8.51	4.15	9.04	5.23	.00	4.36
	Average	12.33	7.01	6.92	3.58	8.75	5.59	.25	3.39
4252	Bermuda hay	22.71	18.37	13.10	4.27	18.44	4.34	5.27	8.83
3883	Buffalo grass hay	20.99	16.06	10.40	4.15	16.84	4.93	5.66	6.25
4557	Corn shucks	32.53	20.42	9.92	3.30	29.23	12.11	10.50	6.62
4552	Guam grass	21.74	17.00	11.20	4.18	17.56	4.74	5.80	7.02
3587	Johnson grass hay	20.89	15.18	11.20	4.00	16.89	5.71	3.98	7.30
4238	Johnson grass hay	21.33	16.51	10.72	4.38	16.95	4.82	5.79	6.34
4546	Kafir fodder	19.68	14.63	9.39	3.35	16.33	5.05	5.24	6.04
4247	Millet	20.18	11.03	10.11	4.57	15.61	9.15	.92	5.54
3595	Oat hay	22.94	18.86	10.77	4.25	18.69	4.08	8.09	6.52
4277	Para grass	20.89	15.61	9.73	4.63	16.26	5.28	5.88	5.10
3625	Rice straw	19.90	16.45	9.42	3.85	16.05	3.45	7.03	5.57
4663	Rice straw	20.00	16.22	9.13	3.31	16.69	3.78	6.59	6.32
3224	Sorghum hay	19.79	15.63	9.47	4.13	15.66	4.16	6.16	5.34
	Average	21.04	16.31	10.35	4.03	17.94	5.51	5.92	6.37

Soluble in N/50 Acid and Alkali. The difference between the total pentosans and the pentosans in the residue after the treatment with N/50 acid and alkali, is taken to be pentosans soluble in N/50 acid and alkali.

Soluble in One and One-fourth Per Cent Sulphuric Acid. The difference between the pentosans in the residue from the N/50 acid and alkali and the pentosans in the residue from the 1¼ per cent sulphuric acid, is taken to be the pentosans soluble in 1¼ per cent sulphuric acid. It will be noted that this is the amount soluble *after treatment* with the weak

acid and alkali, and not the total amount dissolved by the 1¼ per cent sulphuric acid.

Dissolved by One and One-fourth Per Cent Caustic Soda. The difference between the pentosans in the residue from the 1¼ per cent sulphuric acid, and the pentosans in the crude fiber is the pentosans dissolved by the 1¼ per cent caustic soda. This is not the entire amount dissolved from the feed by such treatment, but the entire amount less the effect of the weak acid and alkali.

DISTRIBUTION OF PENTOSANS.

Table 1 shows the distribution of the pentosans based upon per cent in the feed, and Table 2 the distribution based upon percentage of the pentosans (total pentosans equal 100 per cent). The feeds are divided into two groups: legumes and non-legumes.

The legumes contain much lower percentages of pentosans than the non-legumes. The average quantity of pentosans in the legumes are about 60 per cent of the average quantity in the non-legumes.

TABLE 2.—PERCENTAGE DISTRIBUTION OF PENTOSANS.

Laboratory No.		In crude fiber.	In Nitrogen-Free Extract.		
			Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
3277	Alfalfa hay	30.8	43.6	0.0	26.9
3609	Bur clover	20.9	49.3	2.2	27.6
3220	Cowpea hay	.....	.....	.....	.....
4259	Peanut hay	29.0	45.4	6.6	19.1
3649	Vetch hay	31.5	39.6	0.0	33.1
	Average	28.1	44.5	2.2	26.7
4252	Bermuda hay	18.8	19.1	23.2	38.9
3883	Buffalo grass hay	19.8	23.5	27.0	29.8
4557	Corn shucks	10.2	37.2	32.3	20.3
4552	Guam grass	19.2	21.8	26.7	32.3
3587	Johnson grass hay	19.2	27.3	19.1	34.5
4238	Johnson grass hay	20.5	22.6	27.1	29.7
4546	Kafir fodder	17.0	25.6	26.7	30.7
4247	Millet	22.6	45.3	4.6	27.5
3595	Oat hay	18.5	17.8	35.3	28.4
4277	Para grass	22.2	25.3	28.1	24.4
3625	Rice straw	19.3	17.3	35.4	28.0
4663	Rice straw	16.5	18.9	32.9	31.6
3224	Sorghum hay	20.9	21.0	31.1	27.0
	Average	18.8	24.8	26.9	29.5

The percentage of pentosans in the crude fiber is a little lower in the legume, based on the total feed, but the pentosans in the crude fiber of the legume make up a much larger percentage of the total pentosans than those in the non-legumes. The average difference is 10 per cent of the total pentosans.

The amount of pentosans dissolved from the feed by N/50 acid and alkali (Table 1) are nearly the same. The percentage of total pentosans dissolved (Table 2) averages 44.5 for the legumes, 24.8 for the

non-legumes. One non-legume (millet) has a solubility equal to the legumes. The pentosans of legumes are thus much more easily soluble in weak reagents than those of non-legumes.

The pentosans dissolved by the 1¼ per cent sulphuric acid from the legumes are much less than from the non-legumes. This is perhaps due to the more easily soluble nature of the pentosans in the non-legumes, leaving less to be dissolved by the acid.

The percentage of pentosans dissolved from the feeds by 1¼ per cent caustic soda with legumes is about 50 per cent of that dissolved from the non-legumes (Table 1) but the per cent dissolved of the *pentosans* (Table 2) is nearly the same.

To sum up, we may say that the legumes contain much less pentosans than the non-legumes, of which a portion is much more easily soluble in weak acid and alkali, and at the same time a portion is less soluble in stronger acids, so that a greater proportion remains in the crude fiber. The work thus brings out decided differences in the distribution of pentosans in legumes and non-legumes.

DIGESTIBILITY.

The digestibility of the pentosans is worked out in Table 13. Table 1 shows the pentosans in the feeds and Table 4 the composition of the excrements. The residues were assumed to have the same composition as the feeds. The average co-efficients of digestibility are given in Table 3.

TABLE 3.—COEFFICIENTS OF DIGESTIBILITY.

Laboratory No.		Total.	In crude fiber.	In Nitrogen-Free Extract			
				Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
3277	Alfalfa hay	56.46	41.65	63.06	75.74	0	41.09
3609	Bur clover	76.22	62.70	79.78	87.65	96.82	63.99
3220	Cowpea hay	54.94	51.90	56.42	.....	.....	.....
4259	Peanut hay	66.04	49.49	72.80	88.38	68.04	37.26
3649	Vetch hay	61.11	60.17	61.59	71.04	0	61.75
	Average	62.95	53.18	66.73	80.70	41.22	51.02
4252	Bermuda hay	45.73	56.39	43.25	55.08	32.65	45.39
3883	Buffalo grass hay	56.85	61.65	54.66	65.38	53.73	49.82
4557	Corn shucks	71.05	59.90	72.32	80.87	69.78	62.29
4552	Guam Grass	50.86	64.67	47.60	60.23	39.91	45.45
3587	Johnson grass hay	63.14	65.74	62.51	65.64	55.01	64.32
4238	Johnson grass hay	63.97	64.34	63.88	76.02	58.80	59.09
4546	Kafir fodder	66.23	66.09	66.25	81.35	66.66	56.70
4247	Millet	61.23	68.24	59.18	84.50	0	42.86
3595	Oat hay	71.53	74.11	70.95	73.16	78.68	59.98
4277	Para grass	42.62	57.12	38.48	49.73	50.49	12.98
3625	Rice straw	48.37	59.02	45.49	45.63	54.60	34.91
4663	Rice straw	48.96	55.77	47.63	51.66	46.99	45.71
3224	Sorghum hay	64.71	63.90	65.27	71.27	76.31	47.85
	Average	58.10	62.92	56.73	66.19	52.59	48.26

The total pentosans of the legumes are, on an average, digested to a greater extent than those of the non-legumes. There are, however, a

number of non-legumes, in which the total pentosans are digested as much as the pentosans of legumes, or more. These include corn shucks, Johnson grass hay, kafir fodder, oat hay and sorghum hay.

The pentosans of the crude fiber of the non-legumes are digested to a greater extent than the pentosans of the crude fiber of the legumes.

TABLE 4.—PENTOSANS IN PER CENT OF THE EXCREMENT.

Laboratory No.		Total.	In corn fiber.	After 14% sulphuric acid.	In crude fiber.	Total in nitrogen free extract.	In Nitrogen-Free Extract.		
							Soluble in N/50 acid and alkali.	Soluble in 14% sulphuric acid.	Soluble in 14% caustic soda.
3222	Excrement Sheep 2	11.94	.....	.....	4.20	7.74	.....	.....	.....
3223	" " " 3	11.87	.....	.....	4.20	7.67	.....	.....	.....
3258	" " " 1	18.50	14.79	11.40	4.03	14.47	3.71	3.39	7.37
3259	" " " 2	18.46	15.64	11.69	4.08	14.38	2.82	3.95	7.61
3260	" " " 3	18.22	15.31	11.08	4.05	14.17	2.91	4.23	7.03
3279	" " " 2	15.63	11.70	11.63	6.63	9.00	3.93	.07	5.00
3280	" " " 3	15.64	11.99	12.10	6.26	9.38	3.65	.00	5.84
3281	" " " 4	15.79	11.95	12.80	6.52	9.27	3.84	.00	6.28
3589	" " " 1	15.24	12.30	8.45	2.83	12.41	2.94	3.85	5.62
3590	" " " 3	16.28	11.78	8.12	2.79	13.49	4.50	3.66	5.33
3591	" " " 4	16.78	11.91	8.16	2.99	13.79	4.87	3.75	5.17
3597	" " " 1	17.91	14.40	9.30	3.10	14.81	3.51	5.10	6.20
3598	" " " 4	18.74	16.04	11.40	3.08	15.66	2.70	4.64	8.32
3623	" " " 2	10.79	8.18	8.29	3.65	7.14	2.61	.00	4.64
3624	" " " 3	10.78	7.87	7.80	3.42	7.36	2.91	.07	4.38
3700	" " " 1	13.76	9.70	8.92	4.44	9.32	4.06	.78	4.48
3877	" " " 2	17.76	14.48	9.33	2.72	15.04	3.28	5.15	6.61
3878	" " " 3	18.48	15.28	8.51	2.97	15.51	3.20	6.77	5.54
3879	" " " 4	18.45	14.94	9.90	2.68	15.77	3.51	5.04	7.22
3885	" " " 2	19.70	15.81	10.19	3.26	16.44	3.89	5.62	6.93
3886	" " " 3	20.40	16.19	10.31	3.53	16.87	4.21	5.88	6.78
3887	" " " 4	19.33	16.21	10.53	3.64	15.69	3.12	5.68	6.89
4240	" " " 1	19.66	16.45	10.39	3.87	15.79	3.21	6.06	6.52
4241	" " " 2	19.62	16.66	10.58	3.87	15.75	2.96	6.08	6.72
4242	" " " 3	19.22	16.57	10.61	4.12	15.10	2.65	5.96	6.49
4249	" " " 1	18.98	15.65	11.20	3.48	15.50	3.33	4.45	7.72
4250	" " " 3	18.50	14.30	10.48	3.30	15.20	4.20	3.82	7.18
4251	" " " 4	18.92	16.16	11.58	3.65	15.27	2.76	4.58	7.93
4254	" " " 1	23.71	20.18	13.62	3.69	20.02	3.53	6.56	9.93
4255	" " " 3	24.71	20.47	12.68	3.71	21.00	4.24	7.79	8.97
4256	" " " 4	24.35	20.64	13.25	3.60	20.75	3.71	7.39	9.65
4261	" " " 1	12.45	10.65	9.69	5.36	7.09	1.80	.96	4.33
4262	" " " 3	11.15	9.43	8.63	4.89	6.26	1.72	.80	3.74
4263	" " " 4	11.25	9.36	8.98	4.78	6.47	1.89	.38	4.20
4279	" " " 1	21.65	17.20	11.90	3.87	17.78	4.45	5.30	8.03
4280	" " " 3	22.63	17.28	11.47	3.58	19.05	5.35	5.81	7.89
4281	" " " 4	23.03	17.91	12.72	3.71	19.32	5.12	5.19	9.01
4548	" " " 4	19.22	16.94	11.30	3.20	16.02	2.28	5.64	8.10
4549	" " " 5	18.45	15.70	10.35	3.09	15.36	2.75	5.35	7.26
4550	" " " 6	18.18	15.39	9.88	3.24	14.94	2.79	5.51	6.64
4554	" " " 1	21.26	18.63	10.95	3.00	18.26	2.63	7.68	7.95
4555	" " " 3	22.64	18.02	11.26	3.17	19.47	4.62	6.76	8.09
4556	" " " 5	22.34	17.92	10.73	2.99	19.35	4.42	7.19	7.74
4559	" " " 1	25.52	18.14	9.94	3.40	22.12	7.38	8.20	6.54
4560	" " " 4	24.84	19.47	10.22	3.64	21.20	5.37	9.25	6.58
4561	" " " 5	21.86	16.96	9.20	3.18	18.68	4.90	7.76	6.02
4665	" " " 1	18.33	15.02	8.66	2.74	15.59	3.31	6.36	5.92
4666	" " " 4	19.24	15.65	9.55	2.71	16.53	3.59	6.10	6.84
4667	" " " 5	17.59	14.59	8.25	2.45	15.14	3.00	6.34	5.80

In the legumes the pentosans soluble in N/50 acid and alkali are much more digestible than in the non-legumes. There are several non-legumes, in which these pentosans are highly digested. These include corn shucks, Johnson grass hay, kafir fodder, millet, oat hay, and sorghum hay. If these non-legumes alone were averaged, the average would perhaps be equal to the average for the legumes. It is a significant

fact that the pentosans soluble in N/50 acid and alkali are much more easily digested than the remainder of the pentosans. It is also to be observed that the pentosans in the crude fiber are apparently digested to a greater extent than those soluble in 1¼ per cent sulphuric acid or in 1¼ per cent caustic soda. As pointed out in a previous publication by the writer (North Carolina Bulletin 172), possibly this may be due to processes within the animal making portions of the crude fiber less resistant to the action of acids and alkalies, and thus throwing these portions into the nitrogen-free extract group. This would, of course, decrease the apparent digestibility of the nitrogen-free extract, and increase that apparent digestibility of the crude fiber.

QUANTITIES DIGESTED.

Table 5 shows the quantities of digestible pentosan of the various groups in percentage of the feeding stuffs. The non-legumes contain more digestible pentosans in all the groups except those soluble in N/50 acid and alkali.

TABLE 5.—PERCENTAGE OF DIGESTED PENTOSANS.

Laboratory No.	Name of Feeds.	Total.	In crude fiber.	In Nitrogen-Free Extract.			
				Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
3277	Alfalfa hay	6.14	1.73	5.91	4.47	.00	1.49
3609	Bur clover	9.56	1.64	7.91	5.41	.27	2.21
3220	Cowpea hay	6.20	1.94	4.26	.....	.....	.....
4259	Peanut Hay	7.34	1.59	5.74	4.45	.50	.79
3649	Vetch hay	8.06	2.50	5.57	3.72	.00	2.69
	Average	7.46	1.88	5.88	4.51	.19	1.80
4252	Bermuda hay	10.37	2.41	7.97	2.39	1.72	4.01
3883	Buffalo grass hay	11.93	2.56	9.20	3.22	3.04	3.11
4557	Corn shucks	23.11	1.98	21.14	9.79	7.33	4.12
4552	Guam grass	10.96	2.70	8.36	2.85	2.31	3.19
3587	Johnson grass hay	13.19	2.63	10.56	3.75	2.19	4.70
4238	Johnson grass hay	13.64	2.82	10.83	3.66	3.40	3.75
4546	Kafir fodder	13.03	2.21	10.82	4.11	3.49	3.42
4247	Millet	12.36	3.12	9.23	7.73	.00	2.37
3595	Oat hay	16.41	3.15	13.26	2.98	6.37	3.91
4277	Para grass	8.94	2.64	6.26	2.62	2.97	.66
3625	Rice straw	9.63	2.27	7.30	1.57	3.84	1.94
4663	Rice straw	9.79	1.85	7.95	1.95	3.10	2.89
3224	Sorghum hay	12.81	2.64	10.22	2.96	4.70	2.56
	Average	12.78	2.62	10.23	3.81	3.42	3.13

DESTRUCTION OF PENTOSANS.

Certain considerations, and preliminary work, lead us to contemplate the possibility of the destruction of pentosans by the action of the acid or alkali. Experiments were accordingly made to test this point.

Effect of N/50 Acid. Two grams substance were extracted with ether and boiled with 200 c.c. water and 20 c.c. N/5 acid as previously described for thirty minutes. It was filtered on asbestos. Pentosans were determined in the residue. The filtrate was neutralized with caustic soda, made slightly acid with acetic acid, evaporated to about 100 c.c., 100 c.c. strong hydrochloric acid added, and the estimation of pentosans completed as usual. Results are given in Table 6. With one exception, there is a loss of pentosans due to the digestion with the acid. The average loss is about 9 per cent of the total pentosans.

TABLE 6.—PENTOSANS IN RESIDUE AND FILTRATE FROM N/50 ACID, PER CENT.

Lab. No.		Residue.	Filtrate.	Residue and Filtrate.	Total in Feed.	Loss by Treatment.
3225	Sorghum hay	18.25	1.57	19.82	19.79	0.00
3883	Buffalo grass hay	17.19	1.31	18.50	20.99	2.49
4277	Para grass	18.00	1.86	19.86	20.89	1.03
4559	Excrement, corn shucks	20.90	1.51	22.41	25.52	3.11
4663	Rice straw	17.44	1.21	18.65	20.00	1.35
4665	Excrement, rice straw	16.10	0.87	16.97	18.33	1.36
3279	Excrement, alfalfa	13.63	0.39	14.02	15.63	1.61
3587	Johnson grass hay	15.82	1.28	17.10	20.89	3.79
3589	Excrement, Johnson grass	13.94	0.76	14.70	15.24	0.54
3625	Rice straw	17.62	0.95	18.57	19.90	1.33
4259	Peanut hay	7.68	2.41	10.08	11.11	1.03
	Average	16.05	1.28	.....	18.94	1.60

TABLE 7.—PENTOSANS IN RESIDUE AND FILTRATE FROM N/50 ALKALI, PER CENT.

Lab. No.		A Residue.	B Filtrate.	Residue and Filtrate.	Total in Feed.	Loss by Treatment.
3225	Sorghum hay	17.80	1.15	18.95	19.79	0.84
3883	Buffalo grass hay	17.48	.96	18.44	20.99	2.55
4277	Para grass	18.12	.99	19.11	20.89	1.78
4559	Excrement, corn shucks	20.73	1.61	22.34	25.52	3.18
4663	Rice straw	17.29	.70	18.99	20.00	1.01
4665	Excrement, rice straw	16.47	.64	17.11	18.33	1.22
3279	Excrement, alfalfa	12.29	1.59	13.88	15.63	1.75
3587	Johnson grass hay	16.45	1.19	17.64	20.89	3.25
3589	Excrement, Johnson grass	13.36	0.95	14.31	15.24	0.93
3625	Rice straw	17.94	.62	18.56	19.90	1.34
4259	Peanut hay	7.60	1.95	9.55	11.11	1.56
	Average	15.87	1.12	.....	18.94	1.76

TABLE 8.—PENTOSANS IN RESIDUE AND FILTRATE FROM .125 ACID, PER CENT.

Lab. No.		Residue.	Filtrate.	Residue and Filtrate.	Total in Feed.	Loss by Treatment.
3225	Sorghum hay	16.83	1.82	18.65	19.79	1.14
3587	Johnson grass hay	16.19	1.41	17.60	20.89	3.29
3625	Rice straw	16.41	1.15	17.56	19.90	2.34
3883	Buffalo grass hay	16.06	1.47	17.53	20.99	3.46
4259	Peanut hay	7.11	2.75	9.86	11.11	1.25
4277	Para grass	17.28	1.91	18.99	20.89	1.90
	Average	14.81	1.75	.....	18.93	2.23

Effect of N/50 Alkali. The material was digested, and pentosans estimated in filtrate and residue, as described above except that N/5 sodium hydroxide was used instead of hydrochloric acid. Results are presented in Table 7. A loss occurred in all cases. The average loss is about 11 per cent of the total pentosans.

Effect of 0.125 Per Cent Acid. The material was digested as described above and pentosans estimated in filtrates and residues, excepting that 20 c.c. 1¼ per cent sulphuric acid was used in place of 20 c.c. N/5 hydrochloric acid. Results are in Table 8. In comparison with the N/50 acid or alkali, there is a somewhat greater loss.

Effect of 0.125 Alkali. The method is described above, except 1¼ per cent caustic soda was used. Results are in Table 9.

Effect of One and One-fourth Per Cent Acid. The method is as previously described, except that 200 c.c. 1¼ per cent sulphuric acid was used. Results are in Table 10. Much more pentosans are dissolved by the 1¼ per cent sulphuric acid than by the N/50 acid, but the loss of pentosans is a little less.

TABLE 9.—PENTOSANS IN RESIDUE AND FILTRATE FROM .125 ALKALI, PER CENT.

Lab. No.		Residue.	Filtrate.	Residue and Filtrate.	Total Pentosans.	Loss by Treatment.
3225	Sorghum hay	17.96	1.57	19.53	19.79	1.26
3587	Johnson grass hay	16.82	1.99	18.81	20.89	2.08
3625	Rice straw	17.29	0.96	18.25	19.90	1.65
3883	Buffalo grass hay	16.24	1.50	17.74	20.99	3.25
4259	Peanut hay	7.71	1.65	9.36	11.11	8.75
4277	Para grass	17.65	1.90	19.55	20.89	1.34
	Average	15.61	1.60	.....	18.93	3.06

TABLE 10.—PENTOSANS IN RESIDUE AND FILTRATE FROM 1 1-4 PER CENT ACID, PER CENT.

Lab. No.		Residue.	Filtrate.	Residue and Filtrate.	Original Total.	Loss.
3277	Alfalfa	9.36	3.88	13.24	13.53	0.29
3279	Excreta, alfalfa	12.06	1.93	13.99	15.63	1.64
3587	Johnson grass hay	9.42	8.88	18.30	20.89	2.59
3589	Excreta, Johnson grass	7.59	7.39	14.98	15.24	0.26
3625	Rice straw	9.58	8.63	18.21	19.90	1.69
4259	Peanut hay	5.46	4.57	10.03	11.11	1.08
3225	Sorghum hay	9.86	9.52	19.38	19.79	0.41
3883	Buffalo grass hay	9.13	7.86	16.97	20.99	4.02
4277	Para grass	10.61	9.21	19.82	20.89	1.07
4559	Excreta	10.11	13.66	23.77	25.52	1.75
4663	Rice straw	9.34	9.56	18.90	20.00	1.10
4665	Excreta	8.49	9.04	17.53	18.33	0.80
	Average	9.25	7.84	.....	18.49	1.39

Effect of One and One-fourth Per Cent Alkali. The method is as described, except that 200 c.c. of 1¼ per cent caustic soda was used.

Results are in Table 11. The alkali dissolves less pentosans than the acid but has a somewhat greater destructive action.

Discussion of Results.

The average loss of pentosans by treatment with N/50 acid is 8.4 per cent of the total, and by N/50 alkali, 9.3 per cent. The loss by treatment with 0.125 per cent acid was 11.2 per cent, and with 0.125 per cent alkali, 16.2 per cent, somewhat more. The loss with 1¼ per cent acid was 7.5 per cent, and with 1¼ per cent alkali, 13.5 per cent. The same samples were used in the averages compared, though the pairs were somewhat different from each other and for this reason all the averages may not be compared directly with one another. When all these facts are taken into consideration, the error of analysis included, we may conclude that the stronger reagents have little (if any) more destructive action upon the pentosans than the weaker ones, and that the alkali may have a little stronger destructive action than the acid. It is, of course, impossible to say whether the pentosan is destroyed after it is dissolved, or if it is so changed by the reagent that it no longer produces furfural, and the product remains insoluble.

The term "pentosan" was used advisedly in the discussion above. The substance destroyed may very possibly not be a pentosan at all, but may be a pseudo-pentosan, or even a substance which does not yield furfural on distillation, but some substance resembling it.

TABLE 11.—PENTOSANS IN RESIDUE AND FILTRATE FROM 1 1-4 PER CENT ALKALI, PER CENT.

Lab. No.		Residue.	Filtrate.	Residue and Filtrate.	Original Total.	Loss by Treatment.
3225	Sorghum hay	9.70	8.65	18.31	19.79	1.48
3883	Buffalo grass	7.79	6.80	14.59	20.99	6.40
4277	Para grass	11.72	8.23	19.95	20.89	0.94
4559	Excreta	12.86	10.21	23.07	25.52	2.45
4663	Rice straw	10.66	7.95	18.61	20.00	1.39
4665	Excreta	9.22	7.77	16.99	18.33	1.34
3277	Alfalfa hay	6.33	4.15	10.48	13.53	3.05
3279	Excreta	8.88	4.07	12.95	15.63	2.68
3587	Johnson grass hay	8.65	8.43	17.08	20.89	3.81
3589	Excreta	6.76	7.53	14.29	15.24	0.95
3625	Rice straw	10.05	7.29	17.34	19.90	2.56
4259	Peanut hay	4.77	3.25	8.02	11.11	3.09
	Average	9.95	7.03	.....	18.49	2.51

FURALOID.

It has been shown by the writer (North Carolina Bulletin 178), that the distillate of feeds with hydrochloric acid contains, besides furfural, substances which are destroyed by a subsequent distillation with hydrochloric acid and which are also destroyed by digestion with 1¼ per cent sulphuric acid. The term furaloid has been applied to the mother-substance of this substance assumed to be found in feeds.

The following method was used: Three grams substance was distilled with hydrochloric acid as for pentosans, and the distillate transferred to a 500 c.c. flask and made up to volume, 250 c.c. was transferred to a precipitating jar, 100 c.c. hydrochloric acid added, and precipitated with phloroglucinol, etc., as usual.

The remainder of the distillate was allowed to stand over night, transferred to a distillation flask, and distilled nearly to dryness. Then 50 c.c. acid was added, and distilled nearly to dryness. A second 50 c.c. acid was added and distilled. The distillate was precipitated with phloroglucinol and the determination completed as usual. The results are given in Table 12. It will be noted that in several cases the total pentosans are materially below those previously given but this is due to the method of distillation used for the purposes of the experiment, and perhaps also to the method of calculation. The comparison is, of course, more accurate if made on two portions of the same distillate than if made on two portions of the same feed distilled separately.

The loss on distillation in percentage of total pentosan is remarkably uniform. The average loss is 11.7 per cent. The materials used are different. Loss of pentosans in boiling with 1¼ per cent acid was 7.5 per cent, and with 1¼ per cent alkali, 13.5 per cent, the averages not being drawn from the same feeds. The substances destroyed on redistillation are approximately the same in quantity as the pentosans lost in boiling with acid or alkali. The quantity of the latter lost is not increased materially by increase in the strength of the acid or alkali.

TABLE 12.—PENTOSANS—DIRECTLY AND DISTILLATE—DISTILLED, IN PER CENT OF FEED.

Lab. No.		Original.	Distilled.	Loss.	Per Cent Lost.
3224	Sorghum hay	19.24	17.07	2.17	11.3
3258	Excrement, sorghum hay	16.87	15.21	1.66	9.8
3277	Alfalfa hay	12.07	10.77	1.30	10.7
3279	Excrement, alfalfa	14.12	12.20	1.92	13.6
3587	Johnson grass hay	16.20	14.28	1.92	11.8
3589	Excrement, Johnson grass	15.13	13.24	1.89	12.5
3596	Oat hay	20.15	17.69	2.46	12.2
3597	Excrement, oat hay	16.34	14.63	1.71	10.5
3609	Burr clover	10.77	8.88	1.89	17.5
3623	Excrement, bur clover	10.12	8.59	1.53	15.1
3625	Rice straw	18.64	16.39	2.25	12.1
3877	Excrement, rice straw	16.35	13.91	2.44	14.9
4252	Bermuda hay	22.33	19.78	2.55	11.4
4254	Excrement, Bermuda hay	22.67	20.48	2.19	9.7
4259	Peanut hay	10.64	9.27	1.37	12.9
4261	Excrement, peanut hay	11.68	10.44	1.24	10.6
4546	Kafir fodder	18.88	17.25	1.63	8.6
4548	Excrement, kafir fodder	19.00	17.24	1.76	9.3
4552	Guam grass	19.35	17.22	2.13	11.0
4554	Excrement, Guam grass	19.29	17.00	2.29	11.8
4559	Corn shucks	28.69	25.61	3.08	10.7
4559	Excrement, corn shucks	22.63	20.13	2.50	11.0
4663	Rice straw	18.54	16.35	2.19	11.8
4665	Excrement, rice straw	16.84	14.85	1.99	11.8
	Average			2.00	11.7

Consideration of these facts leads to the conclusion that the "pentosans" which are destroyed on boiling with acid or alkali may be the same substances (furaloids) which give rise to the materials in the distillate, which are destroyed by a redistillation, and which have pre-

viously been shown to be destroyed by digestion with 1¼ per cent sulphuric acid. Further investigations are required for the purpose of studying this point.

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES.

			In Nitrogen-Free Extract.			
	Total.	In Crude Fiber.	Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% caustic soda.	Soluble in 1¼% sulphuric acid.
Digestion Period No. 1 With Cowpea Hay.						
Sheep No. 1—						
Fed 4000 gms. No. 3220-1	451.2	149.2	302.0			
Excreted 1729 gms. No. 2 No. 3222	206.4	72.6	133.8			
Digested	244.8	76.6	168.2			
Percentage digested	54.25	51.34	55.69			
Sheep No. 2—						
Fed 4000 gms. No. 3220-1	451.2	149.2	302.0			
Excreted 1687 gms. No. 3 No. 3223	200.2	70.9	129.4			
Digested	251.0	78.3	172.6			
Percentage digested	55.63	52.48	57.15			
Average	54.94	51.91	56.42			
Digestion Period No. 2 With Sorghum Hay.						
Sheep No. 1—						
Fed 4800 gms. No. 3224-5	949.9	189.5	751.3	199.7	295.4	256.3
Excreted 1860 gms. No. 3258	344.1	75.0	269.1	69.0	63.1	137.1
Digested	605.8	124.2	482.2	130.7	232.3	119.2
Percentage digested	63.78	65.54	64.18	65.46	78.64	46.51
Sheep No. 2—						
Fed 4000 gms. No. 3224-5	791.6	165.2	626.4	166.4	246.4	213.6
Excreted 1560 gms. No. 3259	288.0	63.6	224.3	44.0	61.6	80.3
Digested	503.6	101.6	402.1	122.4	184.8	94.9
Percentage digested	63.62	61.50	64.19	73.55	75.00	44.43
Sheep No. 3—						
Fed 4000 gms.	291.6	165.2	626.4	166.4	246.4	213.6
Excreted 1440 gms. No. 3260	262.4	58.3	204.0	41.9	60.9	101.2
Digested	528.2	106.7	422.4	124.3	185.5	112.4
Percentage digested	66.73	64.67	67.43	74.79	75.28	52.62
Average	64.71	63.90	65.27	71.27	76.31	47.85
Digestion Period No. 3 With Alfalfa Hay.						
Sheep No. 2—						
Fed 4400 gms. No. 3277-8	594.9	183.2	411.6	259.4	0.0	160.0
Excreted 1667 gms, No. 3279	260.6	110.5	150.0	65.5	1.1	83.3
Digested	334.3	72.7	261.6	193.9	—1.1	76.7
Percentage digested	56.19	39.68	63.55	74.75	0.0	47.94
Sheep No. 3—						
Fed 4400 No. 3277-8	595.3	183.4	411.9	259.6	0.0	160.1
Excreted 1511 gms. No. 3280	236.3	94.6	141.7	55.2	0.0	88.2
Digested	359.0	88.8	270.2	204.4	0.0	71.9
Percentage digested	60.31	48.41	65.60	78.74	0.0	44.91

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

	Total.	In Crude Fiber.	In Nitrogen-Free Extract.			
			Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestion Period No. 3 With Alfalfa Hay.						
Sheep No. 4—						
Fed 4400 gms. No. 3277-8.						
Residue 86 gms. No. 3283.						
Eaten	580.6	178.8	401.7	253.1	0.0	156.2
Excreted 1732 gms. No. 3281	273.5	112.9	160.5	66.5	0.0	108 7
Digested	307.1	65.9	241.2	186.6	0.0	47.5
Percentage digested	52.89	36.86	60.04	73.73	0.0	30.41
Average	56.46	41.65	63.06	75.74	0.0	41.09
Digestive Period No. 4 With Johnson Grass Hay.						
Sheep No. 1—						
Fed 3600 No. 3587-8	752.0					
Residue 110 gms. No. 3592	8.8					
Eaten	743.2	142.7	600.5	202.9	141.9	256.4
Excreted 1720 gms. No. 3589	262.1	48.7	213.4	50.6	66.2	96.6
Digested	481.1	94.0	387.1	152.3	75.7	159.8
Percentage digested	64.74	65.87	64.46	75.06	53.35	62.32
Sheep No. 3—						
Fed 3600 gms. No. 3687-8	752.0					
Residue 471 gms. No. 3593	115.3					
Eaten	636.7	122.2	514.4	173.8	121.6	219.6
Excreted 1476 gms. No. 3590	240.3	41.2	199.1	66.3	54.0	78.6
Digested	396.4	81.0	315.3	107.5	67.6	141.0
Percentage digested	62.26	66.20	61.29	61.85	55.59	64.21
Sheep No. 4—						
Fed 3600 gms. No. 3587-8	752.0					
Residue 158 gms. No. 3594	21.2					
Eaten	730.8	140.3	590.5	199.5	139.6	252.1
Excreted 1637 gms. 3591	274.7	48.9	225.7	79.7	61.3	84.6
Digested	456.1	91.4	364.8	119.8	78.3	167.5
Percentage digested	62.41	65.15	61.78	60.05	56.09	66.44
Average	63.14	65.74	62.51	65.64	55.01	64.32
Digestion Period No. 5 With Oat Hay.						
Sheep No. 1—						
Fed 4000 gms. No. 3595-6	917.6					
Residue 173 gms. No. 3599	34.8					
Eaten	882.8	163.3	719.5	157.1	311.6	250.7
Excreted 1281 gms. No. 3597	229.4	39.7	189.7	45.0	65.3	79.4
Digested	653.4	123.6	529.8	112.1	246.3	171.3
Percentage digested	74.01	75.69	73.63	71.36	79.04	68.33
Sheep No. 4—						
Fed 4000 gms. No. 3595-6	917.6					
Residue 242 gms. No. 3600	49.9					
Eaten	867.7	160.5	707.2	154.5	306.3	246.4
Excreted 1433 gms. No. 3598	268.5	44.1	224.4	38.7	66.4	119.2
Digested	599.2	116.4	482.8	115.8	239.9	127.2
Percentage digested	69.05	72.52	68.27	74.95	78.32	51.62
Average	71.53	74.11	70.95	73.16	78.68	59.98

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

	Total.	In Crude Fiber.	In Nitrogen-Free Extract.			
			Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestive Period No. 6 With Burr Clover.						
Sheep No. 2—						
Fed 4000 gms. No. 3609-10	501.6					
Residue 5 gms	0.6					
Eaten	501.0	104.7	396.2	247.0	11.0	138.2
Excreted 1096 gms. No. 3623	118.3	40.0	78.2	28.6	0.0	50.8
Digested	382.7	64.7	318.0	218.4	11.0	87.4
Percentage digested	76.40	61.80	80.24	88.40	100.00	63.24
Sheep No. 3—						
Fed 4000 gms. No. 3609-10	501.6					
Residue 15 gms	1.9					
Eaten	499.7	104.4	395.2	246.4	11.0	137.9
Excreted 1110 gms. No. 3624	119.7	38.0	81.7	32.3	.7	48.6
Digested	380.0	66.4	313.5	214.1	10.3	89.3
Percentage digested	76.04	63.60	79.32	86.89	93.63	64.75
Average	76.22	62.70	79.78	87.65	96.82	63.99
Digestion Period No. 7 With Rice Straw.						
Sheep No. 2—						
Fed 3600 gms. No. 3625-6	716.4	.....	577.8	.....	253.0	200.5
Residue 53 gms. No. 3880	11.0	.....	.....	.....	.....	.....
Eaten	705.4	136.1	569.2	122.0	249.7	197.5
Excreted 1914 gms. No. 3877	339.9	52.1	287.8	62.8	98.5	126.5
Digested	365.5	84.0	281.4	59.2	151.2	71.0
Percentage digested	51.81	61.71	49.43	48.52	60.55	35.95
Sheep No. 3—						
Fed 3600 gms.	716.4	.....	577.8	.....	253.0	200.5
Residue 305 gms. No. 3881	65.2	.....	.....	.....	.....	.....
Eaten	651.2	125.7	525.5	112.6	230.5	182.3
Excreted 1933 gms. No. 3878	357.2	57.4	299.8	61.9	130.8	107.1
Digested	294.0	68.3	225.7	50.7	99.7	75.2
Percentage digested	45.15	54.34	42.95	45.03	43.25	41.25
Sheep No. 4—						
Fed 3600 gms. No. 3625-6	716.4	.....	577.8	.....	253.0	200.5
Residue 170 gms. No. 3882	36.1	.....	.....	.....	.....	.....
Eaten	680.3	131.3	549.0	117.7	240.8	190.4
Excreted 1912 gms. No. 3879	352.8	51.2	301.5	66.7	96.3	138.0
Digested	327.5	80.1	247.5	51.0	144.5	52.4
Percentage digested	48.14	61.01	44.08	43.33	60.01	27.52
Average	48.37	59.02	45.49	45.63	54.60	34.91
Digestion Period No. 8 With Vetch Hay.						
Sheep No. 1—						
Fed 4000 gms. No. 3649-50	527.6	166.2	361.6	208.9	0.0	174.4
Excreted 1491 gms. No. 3700	205.2	66.2	138.9	60.5	11.6	66.7
Digested	322.4	100.0	222.7	148.4	—11.6	107.7
Percentage digested	61.11	60.17	61.59	71.04	0.0	61.75

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

	Total.	In Crude Fiber.	In Nitrogen-Free Extract.			
			Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestion Period No. 9 With Buffalo Grass Hay.						
Sheep No. 2—						
Fed 4000 gms. No. 3883-4	839.6	166.2	673.6	197.3	226.4	250.0
Excreted 1701 gms. No. 3885	335.1	55.5	279.6	66.2	95.6	117.8
Digested	504.5	110.7	394.0	131.1	130.8	132.2
Percentage digested	60.09	66.61	58.48	66.41	57.73	52.88
Sheep No. 3—						
Fed 4000 gms. No. 3883-4	839.6	.....	673.6	.....	226.4	250.0
Residue 5 gms	1.0	.....	.....	.....	.....	.....
Eaten	838.6	166.0	672.5	197.1	226.4	249.9
Excreted 1881 gms. No. 3886	383.7	66.4	317.3	79.2	110.6	127.5
Digested	454.9	99.6	355.2	117.9	115.8	122.4
Percentage digested	54.24	60.00	52.82	59.82	51.15	48.99
Sheep No. 4—						
Fed 4000 gms. No. 3883-4	839.6	.....	673.6	.....	226.4	250.0
Residue 32. gms	6.7	.....	.....	.....	.....	.....
Eaten	832.9	164.9	667.9	195.7	224.8	248.2
Excreted 1887 gms. No. 3887	364.8	68.7	296.0	58.9	107.2	130.1
Digested	468.1	96.2	371.9	136.8	117.6	118.1
Percentage digested	56.21	58.34	55.68	69.90	52.31	47.58
Average	56.85	61.65	54.66	65.38	53.73	49.82
Digestion Period No. 10 With Johnson Grass Hay.						
Sheep No. 1—						
Fed 4000 gms. No. 4238-9	853.2					
Residue 10 gms	2.1					
Eaten	851.1	174.5	676.6	192.3	230.6	252.7
Excreted 1512 gms. No. 4240	297.3	58.5	238.7	48.5	91.6	98.6
Digested	553.8	116.0	437.9	143.8	139.0	154.1
Percentage digested	65.07	66.48	64.72	74.78	60.28	60.98
Sheep No. 3—						
Fed 4000 gms. No. 4238-9	853.2					
Residue 5 gms	1.1					
Eaten	852.1	174.7	677.4	192.6	230.9	253.0
Excreted 1577 gms. No. 4241	309.4	61.0	248.3	46.7	95.9	105.8
Digested	542.7	113.7	429.1	145.9	135.0	147.2
Percentage digested	63.69	65.06	63.34	75.75	58.47	58.18
Sheep No. 4—						
Fed 4000 gms. No. 4238-9	853.2					
Residue 5 gms	1.1					
Eaten	852.1	174.7	677.4	192.6	230.9	253.0
Excreted 1634 gms. No. 4242	314.1	67.3	246.7	43.3	97.8	106.0
Digested	538.0	107.4	430.7	149.3	133.1	147.0
Percentage digested	63.14	61.48	63.58	77.52	57.64	58.10
Average	63.97	64.34	63.88	76.02	58.80	59.09

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

	Total.	In Crude Fiber.	In Nitrogen-Free Extract.			
			Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestion Period No. 11 With Millet.						
Sheep No. 1—						
Fed 4000 gms. No. 4247-8	807.2	.....	624.4	.....	36.8	221.6
Residue 34 gms	6.9	.....	.....	.....	.....	.....
Eaten	800.3	180.9	619.4	362.5	36.8	220.0
Excreted 1686 gms. No. 4249	320.0	58.7	261.3	56.1	75.0	130.1
Digested	480.3	122.2	358.1	306.4	—38.2	89.9
Percentage digested	60.01	67.55	57.81	84.52	0.0	40.86
Sheep No. 3—						
Fed 4000 No. 4247-8	807.2	.....	624.4	.....	36.8	221.6
Residue 20 gms	4.4	.....	.....	.....	.....	.....
Eaten	802.8	181.4	621.3	363.6	36.9	220.7
Excreted 1564 gms. No. 4250	289.3	51.6	237.7	65.7	59.7	112.3
Digested	513.5	129.8	383.6	297.9	—22.8	108.4
Percentage digested	63.96	71.55	61.74	81.93	0.0	49.11
Sheep No. 4—						
Fed 4000 gms. No. 4247-8	807.2	.....	624.4	.....	36.8	221.6
Residue 30 gms	6.6	.....	.....	.....	.....	.....
Eaten	800.6	180.9	619.6	362.6	36.8	220.1
Excreted 1704 gms. No. 4251	322.4	62.2	260.2	47.0	78.0	135.1
Digested	478.2	118.7	359.4	315.6	.....	85.0
Percentage digested	59.73	65.63	58.00	87.04	0.0	38.62
Average	61.23	68.24	59.18	84.50	.....	42.86
Digestion Period No. 12 With Bermuda Hay.						
Sheep No. 1—						
Fed 4000 gms. No. 4252-3	908.4					
Residue 12 gms	2.7					
Eaten	905.7	170.3	735.4	173.0	210.1	352.3
Excreted 1920 gms. No. 4254	455.2	70.8	384.4	67.8	125.9	190.6
Digested	450.5	99.5	351.0	105.2	84.2	161.7
Percentage digested	49.74	58.43	47.73	60.81	40.08	45.90
Sheep No. 3—						
Fed 4000 gms. No. 4252-3	908.4					
Residue 12 gms	2.7					
Eaten	905.7	170.3	735.4	173.0	210.1	352.3
Excreted 2110 gms. No. 4255	521.4	78.3	443.1	89.5	164.3	189.2
Digested	384.3	92.0	292.3	83.5	45.8	163.1
Percentage digested	42.43	54.02	39.75	48.27	21.80	46.30
Sheep No. 4—						
Fed 4000 gms. No. 4252-3	908.4					
Residue 15 gms	3.4					
Eaten	905.0	170.1	734.8	172.9	209.9	352.0
Excreted 2044 gms. No. 4256	497.7	73.6	424.1	75.8	151.0	197.2
Digested	407.3	96.5	310.7	97.1	58.9	154.8
Percentage digested	45.01	56.73	42.28	56.16	28.06	43.98
Average	45.73	56.39	43.25	55.08	32.65	45.39

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

			In Nitrogen-Free Extract.			
	Total.	In Crude Fiber.	Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestion Period No. 13 With Peanut Hay.						
Sheep No. 1—						
Fed 4000 gms. No. 4259-60	444.4	128.9	315.6	201.8	29.2	84.8
Excreted 1335 gms. No. 4261	166.2	71.6	94.6	24.0	12.8	57.8
Digested	278.2	57.3	221.0	177.8	16.4	27.0
Percentage digested	62.65	44.45	70.03	88.10	56.17	31.84
Sheep No. 3—						
Fed 4000 gms. No. 4259-60	444.4	128.9	315.6	201.8	29.2	84.8
Excreted 1246 gms. No. 4262	138.9	60.9	78.0	21.4	10.0	46.6
Digested	305.5	68.0	237.6	180.4	19.2	38.2
Percentage digested	68.74	52.75	75.29	89.39	65.75	45.05
Sheep No. 4—						
Fed 4000 gms. No. 4259-60	444.4	128.9	315.6	201.8	29.2	84.8
Excreted 1315 gms. No. 4263	147.9	62.8	85.0	24.9	5.0	55.2
Digested	296.5	66.1	230.6	176.9	24.0	29.6
Percentage digested	66.72	51.28	73.07	87.66	82.19	34.90
Average	66.04	49.49	72.80	88.38	68.04	37.26
Digestion Period No. 14 With Para Grass.						
Sheep No. 1—						
Fed 4000 gms. No. 4277-8	835.6					
Residue 212 gms.	43.2					
Eaten	792.4	175.9	616.5	200.5	222.6	193.3
Excreted 2043 gms. No. 4279	442.3	79.1	363.2	90.9	108.2	164.0
Digested	350.1	96.8	253.3	109.6	114.4	29.3
Percentage digested	44.18	55.03	41.09	54.66	51.39	15.16
Sheep No. 3—						
Fed 4000 gms. No. 4277-8	835.6					
Residue 40 gms. No. 4283	7.9					
Eaten	827 7	183.7	643.9	209.4	232.5	201.9
Excreted 2175 gms. No. 3 4280	492.2	77.9	414.3	116.4	126.3	171.6
Digested	335.5	105.8	229.6	93.0	106.2	30.3
Percentage digested	40.53	57.59	35.65	44.42	45.68	15.01
Sheep No. 4—						
Fed 4000 gms. No. 4277-8	835.6					
Residue 648 gms. No. 4284	126.3					
Eaten	709.3	157.5	551.8	179.4	199.3	173.0
Excreted 1751 gms No. 4281	403.3	65.0	338.3	89.5	90.9	157.8
Digested	306.0	92.5	213.5	89.9	108.4	15.2
Percentage digested	43.14	58.73	38.69	50.11	54.39	8.78
Average	42.62	57.12	38.48	49.73	50.49	12.98
Digestion Period No. 15 With Kafir Fodder.						
Sheep No. 4—						
Fed 4000 gms. No. 4546	787.2	133.8	653.2	201.5	210.2	241.6
Excreted 1409 gms. No. 4548	270.8	45.1	225.7	32.1	79.4	114.1
Digested	516.4	88.7	427.5	168.4	130.8	127.5
Percentage digested	65.60	66.29	65.44	83.57	62.22	52.77

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

			In Nitrogen-Free Extract.			
	Total.	In Crude Fiber.	Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestion Period No. 15 With Kafir Corn.						
Sheep No. 5—						
Fed 4000 gms. No. 4546-7	787.2	133.8	653.2	201.5	210.2	241.6
Excreted 1433 gms. No. 4549	264.4	44.3	220.1	39.4	76.6	104.0
Digested	522.8	89.5	433.1	162.1	133.6	137.6
Percentage digested	66.40	66.90	66.30	80.44	63.56	56.95
Digestion Period No. 15 With Kafir Fodder.						
Sheep No. 6—						
Fed 4000 gms. No. 4546-7	787.2					
Residue 308 gms. No. 4551	67.9					
Eaten	855.1	145.4	709.7	218.9	228.3	262.5
Excreted 1567 gms. No. 4550	284.9	50.8	234.1	43.7	86.3	104.0
Digested	570.7	94.6	475.6	175.2	142.0	158.5
Percentage digested	66.68	65.08	67.01	80.05	62.20	60.38
Average	66.23	66.09	66.25	81.35	62.60	56.70
Digestion Period No. 16 With Guam Grass.						
Sheep No. 1—						
Fed 4000 gms. No. 4552-3	869.6	167.0	702.4	189.6	232.0	280.8
Excreted 1899 gms. No. 4554	403.7	57.0	346.7	49.9	145.8	150.9
Digested	465.9	110.0	355.7	139.7	86.2	129.9
Percentage digested	53.58	65.86	50.64	73.68	37.15	46.26
Sheep No. 3—						
Fed 4000 gms. No. 4552-3	869.6	162.0	702.4	189.6	232.0	280.8
Excreted 1888 gms. No. 4555	427.4	59.8	367.6	87.2	127.6	152.7
Digested	442.2	107.2	334.8	102.4	104.4	128.1
Percentage digested	50.85	64.19	47.67	54.01	45.00	45.62
Sheep No. 5—						
Fed 4000 gms. No. 4552-3	869.6	167.0	702.4	189.6	232.0	280.8
Excreted 2015 gms. No. 4556	450.1	60.2	389.9	89.1	144.8	155.9
Digested	419.5	106.8	312.5	100.5	87.2	124.9
Percentage digested	48.24	63.95	44.49	53.01	37.59	44.48
Average	50.86	64.67	47.60	60.23	39.91	45.45
Digestion Period No. 17 With Corn Shucks.						
Sheep No. 1—						
Fed 3200 gms. No. 4557-8	1041.0					
Added 45 gms. No. 4557-8	14.6					
Eaten	1055.6	107.7	947.9	392.7	340.9	214.3
Excreted 1350 gms. No. 4559	344.5	45.9	298.6	99.6	110.7	88.3
Digested	711.1	61.8	649.3	293.1	230.2	126.0
Percentage digested	67.36	57.38	68.50	74.64	67.53	58.80
Sheep No. 4—						
Fed 3200 gms. No. 4557-8	1041.0					
Added 12 gms	3.9					
Eaten	1044.9	106.6	938.3	388.7	337.5	212.1
Excreted 1268 gms. No. 4560	315.0	46.2	268.8	68.1	117.3	83.4
Digested	729.9	60.4	669.5	320.6	220.2	128.7
Percentage digested	69.85	56.66	71.35	82.48	65.24	60.68

TABLE 13.—PENTOSANS FED, EATEN, AND DIGESTED, IN GRAMS AND PERCENTAGES—Continued.

	Total.	In Crude Fiber.	In Nitrogen-Free Extract.			
			Total.	Soluble in N/50 acid and alkali.	Soluble in 1¼% sulphuric acid.	Soluble in 1¼% caustic soda.
Digestion Period No. 17 With Corn Shucks.						
Sheep No. 5—						
Fed 3200 gms. No. 4557-8	1041.1					
Added 4 grms.	1.3					
Eaten	1042.3	106.3	935.9	387.7	336.6	211.6
Excreted 1147 gms. No. 4561	250.7	36.5	214.2	56.2	89.0	69.0
Digested	791.6	69.8	721.7	331.5	247.6	142.6
Percentage digested	75.95	65.66	77.11	85.50	73.56	67.39
Average	71.05	59.90	72.32	80.87	69.78	62.29
Digestion Period No. 18 With Rice Straw.						
Sheep No. 1—						
Fed 3200 gms. No. 4663-4	640.0					
Residue 3 gms. No. 4663-4	0.6					
Eaten	639.4	105.5	533.9	120.8	210.3	202.0
Excreted 1691 gms. No. 4665	310.0	46.3	263.6	56.0	107.5	100.1
Digested	329.4	59.2	270.3	64.8	102.8	101.9
Percentage digested	51.52	56.11	50.63	53.64	48.88	50.44
Sheep No. 4—						
Fed 3200 gms. No. 4663-4	640.0					
Added 45 gms. No. 4668	9.2					
Eaten	649.2	107.1	542.0	122.7	213.8	205.1
Excreted 1708 gms. No. 4666	328.6	46.3	282.3	61.3	104.2	116.8
Digested	320.6	60.8	259.7	61.4	109.4	88.3
Percentage digested	49.37	56.77	47.91	50.04	51.22	43.05
Sheep No. 5—						
Fed 3200 gms. No. 4663-4	640.0					
Residue 777 gms. No. 4669	167.6					
Eaten	472.4	77.9	394.4	89.3	155.4	149.3
Excreted 1450 gms. No. 4667	255.1	35.5	219.5	43.5	91.9	84.1
Digested	217.3	42.4	174.9	45.8	63.5	65.1
Percentage digested	46.00	54.43	44.35	51.29	40.86	43.63
Average	48.96	55.77	47.63	51.66	46.99	45.71

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SUMMARY AND CONCLUSIONS.

1. Legumes contain a much lower percentage of pentosans than non-legumes.

2. Approximately 28 per cent of the pentosans of legumes is in the crude fiber, 44.5 per cent is dissolved by N/50 acid and alkali, 2.2 per cent is dissolved by 1¼ per cent sulphuric acid, and 26.7 per cent by 1¼ per cent alkali.

3. On an average, 18.8 per cent of the pentosans of non-legumes are in the crude fiber, 24.8 per cent dissolved by N/50 acid and alkali, 26.9 per cent dissolved by 1¼ per cent sulphuric acid and 29.5 per cent dissolved by 1¼ per cent alkali.

4. The total pentosans of the legumes were on an average digested better than the pentosans of non-legumes, though there were several non-legumes fully up to the average for legumes.

5. The pentosans soluble in N/50 acid and alkali are digested to a greater extent than the remaining pentosans. Those of legumes are on an average considerably more digestible than those of non-legumes.

6. Pentosans in crude fiber are apparently digested to a greater extent than those soluble in 1¼ per cent sulphuric acid or 1¼ per cent caustic soda. This may be due to digestive processes rendering crude fiber more soluble in acid or alkali, and thus throwing a portion of it into the nitrogen-free extract group.

7. Pentosans are destroyed by digestion with hot N/50 acid or alkali, or stronger solutions. The alkali is somewhat more destructive than the acid, but the losses are nearly the same with the stronger or weaker reagent, being about 10 per cent.

8. The "pentosans" which are destroyed by boiling with acid or alkali may be the same substances (furaloids) which give rise to the substances in the hydrochloric acid distillate, which are destroyed by a redistillation.